Geodynamic, depositional and environmental history of the region off the Amery Ice Shelf (Prydz Bay – Kerguelen Plateau Geotransect)

Rationale

The separation of Greater India from Antarctica in early Cretaceous time led to formation of new oceanic gateway between the southern Atlantic (Weddell Sea) and the western Pacific and was accompanied by enormous volcanic eruption of Kerguelen Plateau. The geodynamic and depositional record of these events that greatly affected the Earth's climate is best preserved in the crustal structure and sediment stratigraphy of a large (about 1 million km^2) marine region which is juxtaposed to the Amery Ice Shelf and includes shelf, continental slope and rise of the Prydz Bay and eastern Cooperation Sea, eastern Enderby Abyssal Plain and Southern Kerguelen Plateau.

Prydz Bay lies at the offshore continuation of the Lambert-Amery Graben that marks one of the most extensive intracontinental rifts. The rift formed in Late Jurassic and is now occupied by the world's largest outlet glacier draining about 1 million km^2, or 20% of the EAIS, thus representing a key location for studying both the early history of Gondwana rifting and the Cenozoic glaciation of Antarctica. The Lamber-Aimery failed rift is coupled with a deeply submerged pericontinental rift system beneath continental slope and rise of the Cooperation Sea whose highly extended crust marks the transition to Enderby Abyssal Plain sea-floor formed by Early Cretaceous spreading. The Cenozoic sedimentary cover of deep-water basins contains a complete distal record of the earliest glacial events and associated climate changes known in Antarctica.

A broad sea floor high of the southern Kerguelen Plateau marks one of the two most voluminous LIPs in the Word Ocean and is attributed to Kerguelen Plume/Hotspot emplaced at about 120 Ma ago, or c. 15 Ma after the onset of see-floor spreading between India and Antarctica. At least partly it is underlain by stretched continental crust and itself affected by Late Cretaceous-Early Cenozoic extension. Despite continuous subsidence from early Late Cretaceous to Eocene time, the Kerguelen Plateau remained a shallow marine feature that appreciably influenced the oceanic circulation.

Problems and Objectives

The earlier surveys of the region off the Amery Ice Shelf by national ship-born expeditions (Australia, France, Japan, Russia, USA) and two ODP Legs (119 and 188) revealed the following important questions that are addressed by the proposed study:

Lithosphere Geodynamics

- Structural parameters, physical properties and interrelations of rifted continental, oceanic and volcanic crust;
- Mechanism of extension of continental crust, geometry of rifting and time (onset and duration) of rifting stage;
- Position and nature of continent-to-ocean boundary, timing and geodynamic regime of sea-floor formation, particularly the position of poles of rotation at early stages of sea floor spreading between India and Antarctica;
- Subsidence history of Prydz Bay - Cooperation Sea Basin and its evolution as deep oceanic gateway;
- Tectonic nature of the southern Kerguelen Plateau (oceanic edifice or continental sliver) and the relationship between sea-floor spreading and LIP formation; the mechanism of Kerguelen Plume emplacement ("active" vs. "passive" model).

Depositional History and Environmental Changes

- Age and depositional environments of the major sedimentary units/sequences;
- Development of Cenozoic current-controlled (glacial-related) drifts; fluctuations in the intensity of deep-water circulation;
- Environmental impacts of the Kerguelen Plateau formation and submergence, especially its role in evolution of oceanic gateways (effect on deep-water current deflecting);
- Onset of Antarctic glaciation and EAIS growth history (changes in the glacial regime and sea level as recorded in geometry of prograding sequences); assessment of EAIS stability, especially in the latest Cenozoic (Pliocene-Quaternary).

Research Possibilities, Methods and Logistics

Pursuing the outlined objectives will require combined implementation of available research technologies including variety of geophysical observations and bottom sampling (shallow drilling and/or deep coring). The main emphasis must be made on additional deep-penetrating seismic experiments (MCS profiling with 6-km long streamer and wide-angle reflection/refraction observations using two-ship technology, densely spaced ocean-bottom seismographs and seismic recorders deployed on land/ice). Seismic (MCS, OBS, two-ship) profiles across rift structures, continent-to-ocean transition zone and the southern Kerguelen Plateau will enable characterization of the properties and structure of crystalline crust and upper mantle and high-resolution featuring of seismic stratigraphy and velocities distribution in the sedimentary cover. Broadband seismometer stations along the rift flanks in proximity to Prydz Bay will help to record regional seismicity and local micro-seismicity, as well as to decode a crustal structure from naturally and artificially generated waves.

Airborne geophysical surveys (magnetic in the first place) with densely-spaced flight lines are envisaged to cover key locations of geotransect to provide important information on rift boundaries, position of COB and sea-floor spreading anomalies. Both ship-based helicopters and long-range aircraft flying from the Russian Station “Progress” can be used. Shallow drilling/deep coring will be concentrated on the Prydz Bay shelf to sample major sedimentary units/sequences (both pre-glacial and glacial) most of which in that area crop out in the sea bottom. The short- and long-term glacial history, as well as crucial data on rifting and subsidence history, can be obtained.

The proposed scientific activities can be accomplished using: RV “Akademik Alexander Karpinsky” of PMGRE (equipped by 6 km long digital streamer for MCS profiling), RV Polarstern of AWI (ice-breaking, helicopter-bearing ship with geophysical and coring techniques), and Russian long-range aircraft and helicopters based at “Progress” Station. The latter may simultaneously serve as research platforms and/or transportation means for support of inland aerogeophysical and/or geological activities.

Links with other IPY Projects:

GigaGAP, POGE, IPY Airborne Geophysical Survey.

Project Generation:

German Leitchenkov and Garrik Grikurov, VNIIOkeangeologia, Russia (german_l@mail.ru);
Karsten Gohl, AWI, Germany (kgohl@awi-bremerhaven.de);
Phil O’Brien, AGSO, Australia (Phil.OBrien@agso.gov.au)
Viktor Gandyukhin, PMGRE, Russia (antarctida@peterlink.ru);

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